USAF OEHL REPORT

84-Ø85EH118APB

FOR HEALTH & ENVIRONMENT

AN EVALUATION OF ENGINEERING MODIFICATIONS DESIGNED TO REMOVE AIRBORNE CHLORDANE FROM CRAWL SPACE HOUSES AT MCCONNELL AFB KS

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A study was conducted to evaluate the effectiveness of engineering modifications to remove airborne chlordane in crawl space houses at McConnell AFB. The soil around and under the houses was treated with a 1% chlordane emulsion in 1974 and 1979. The ventilation ducts are located in the crawl space. The following engineering modifications were developed for study: (a) sealing the crawl space soil with a concrete cover, and (b) closing the return air ducts,

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from the crawl space, rerouting the return air inside the house and completely sealing the crawl space from the basement. The modifications were to be tested singularly and in combination.

The study showed that:

a. The correlation between temperature and chlordane concentration found during a previous study was strongly reinforced.

b. The concrete seal or reducting modification reduces chlordane intrusion as well as the combination of them; consequently, the combination modification is not needed.

c. Although there was not a significant statistical difference between the concrete seal and the reducting modifications, the concrete seal can keep chlordane levels below 5 $\mu g/m^3$ at a higher level of confidence.

Concrete sealing of the crawl space soil should be selected as the best engineering modification. That program should be completed before summer temperatures again force higher concentrations to occur. As an interim precaution, polyurethane filters should be installed in all houses with chlordane levels greater than 5 $\mu g/m^3$. Filters shou d be replaced every 30 days. The attached report provides an analysis of the sampling data and a detailed discussion of the recommendations.

Keywords

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USAF OCCUPATIONAL AND ENVIRONMENTAL

HEALTH LABORATORY

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An Evaluation of Engineering Modifications Designed to Remove Airborne Chlordane From Crawl Space Houses at McConnell AFB KS

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Acknowledgement

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I. INTRODUCTION

The USAF Occupational and Environmental Health Laboratory (USAF OEHL) has been investigating the presence of airborne chlordane in military family housing units located on USAF installations at the request of the AF Medical Service Center (AFMSC). All houses surveyed were constructed on soil which had been treated with chlordane as a subterranean termite preventative measure. The initial USAF OEHL effort was directed at houses constructed on a concrete slab with ventilation ducts in or below the slab. Houses treated with chlordane before and/or after construction were evaluated. Chlordane intrusion into the living area of the housing units was found both in houses treated prior to construction[1,2] and in those treated after construction[2,3].

In March 1981, the Bioenvironmental Engineer (BEE) at McConnell AFB KS sampled five houses of the partial basement/partial crawl space design for ambient chlordane levels. The AFMSC had requested the sampling because the crawl space soil had been treated with chlordane. The air samples yielded chlordane, which was the first indication of chlordane intrusion into this type house. Twenty-seven percent of the crawl space houses at McConnell AFB yielded chlordane levels exceeding 5 micrograms of chlordane per cubic meter of air ($\mu g/m^3$), the established guideline.

During June to September 1982, the USAF OEHL conducted a study in twenty crawl space houses at McConnell AFB to determine the effectiveness of polyurethane filters to remove airborne chlordane in houses[4]. The polyurethane filters were installed beside the furnace filter. Although the polyurethane filters adsorbed chlordane, concentrations within most of the houses remained above 5 $\mu g/m^3$ during the summer months.

Following the filter effectiveness study, proposals were made for the USAF OEHL to evaluate the effectiveness of engineering modifications to prevent chlordane intrusion into the living area of the crawl space houses at McConnell AFB.

II. BACKGROUND

A. General

1. Chlordane Information

Chlordane is a member of a group of chlorinated hydrocarbon insecticides generically termed "chlorinated cyclodienes" and is a colorless and odorless liquid. The chlorinated cyclodienes--chlordane, aldrin, dieldrin and heptachlor--are the principal pesticides used for control of subterranean termites. Chlordane has been extensively used in the U.S. for agricultural and household pest control since 1945. The U.S. Air Force, other DOD agencies and the civilian community have employed chlordane as the principal pesticide for subterranean termite control.

In December 1975, the Environmental Protection Agency (EPA) suspended the use of chlordane in the U.S. except for fire ant control, subterranean termite treatment, and the dipping of roots and tops of nonfood plants. Chlordane application for fire ant control was suspended by EPA in December 1980 based upon the persistence of chlordane in the environment and the discovery of its degradation product, heptachlor epoxide, in food, human tissue and wildlife. Many chlorinated hydrocarbons and cyclodienes are persistent and have been reported to be effective termiticides up to 20 years after application. Approximately 20% of originally applied chlordane dosages are recoverable in soil ten years after application. Consequently, the probability for organism exposure to chlordane and the potential for bioaccumulation and biomagnification is greatly enhanced.

2. Chlordane Toxicity

Chlordane can be absorbed through inhalation, ingestion or dermal contact. EPA cited results of experiments with rats and mice show significant increases in cancerous tumors caused by heptachlor epoxide, a metabolite of chlordane. The tumors were found in several organs of these experimental animals, including the liver and endocrine glands. The EPA also noted evidence indicating that heptachlor epoxide in humans is transferred from the mother to the fetus across the placenta. A more recent study by the National Cancer Institute (NCI) concluded that chlordane concentrations of 40 parts per million (ppm) and higher in mice feed caused a significant increase in liver cancer. In contrast, hepatocellular carcinomas failed to appear at a significant incidence in rats. Central nervous system effects--hyperexcitability, tremors and convulsions--have also appeared in laboratory animals fed various cyclodiene class termiticides.

Limited human epidemiological studies involving chronic long-term exposure to chlordane have been confined to the workplace. They have not revealed any consistent or significant detrimental effect from exposure to chlordane[5]. An examination of workers exposed to 1.2 to 1.7 $\mu g/m^3$ for 1-15 years showed no job-related illness among the workers[6]. A similar conclusion followed a study of workers exposed to 10 milligrams of chlordane per cubic meter of air (mg/m^3) for three years[7].

A statistical evaluation of death records for individuals employed by chlordane manufacturers revealed significant excess deaths from cerebrovascular disease, but the researchers emphasized that this should not be accepted as evidence of cause by chlordane exposure without further study[8].

A recent epidemiological study of workers manufacturing chlordane concluded that there was no evidence to indicate that current or past workers are at increased risk for health related problems. However, the suggestion of a trend in cancer deaths with duration of employment indicates that more complete data are needed before firm conclusions can be reached about the human carcinogenicity of chlordane[9].

3. Exposure Standards

The American Conference of Governmental Industrial Hygienists (ACGIH) 1983-84 has adopted a Threshold Limit Value-Time Weighted Average (TLV^R-TWA) of 0.5 mg/m^3 for chlordane in workroom air[10]. This is the allowable

level to which it is believed workers may be continuously exposed in the occupational environment (8 hours/day, 5 days/week) without adverse effect.

The Occupational Safety and Health Administration's (OSHA) permissible workplace exposure limit is also 0.5 mg/m^3. Both agencies noted that chlordane is absorbed through the skin and that dermal exposure should, therefore, be avoided.

Cognizant that neither the ACGIH nor OSHA criteria were applicable to the home environment because of increased exposure time and a significantly different population involved, the Air Force requested the National Academy of Science (NAS) to provide guidance.

In 1979, the NAS Committee on Toxicology concluded that it "could not determine a level of exposure to chlordane below which there would be no biologic effect of prolonged exposure of families in military housing." However, it did suggest an interim airborne concentration of 5 $\mu g/m^3$. The guideline was pragmatically determined on the basis of known concentrations of chlordane in military housing, a review of reported health complaints of residents of contaminated housing, and a comparison with the acceptable daily intake derived from long-term animal feeding studies. The NAS Committee on Toxicology concluded in an August 1982 report that there were no new data to justify a change in the 5 $\mu g/m^3$ guideline[5].

In 1980, EPA initiated a formal risk-benefit review of chlordane to determine whether or not its registered uses for subsurface termite control should be limited or canceled, and whether or not the health of people living in houses treated with chlordane is being adversely affected. The EPA Office of Pesticides and Toxic Substances, Office of Pesticide Programs, published a November 1983 report titled "Analysis of the Risks and Benefits of Seven Chemicals Used for Subterranean Termite Control."[11] In this report, EPA concluded: (a) that a human risk assessment from termiticides cannot be completed due to a lack of definitive health, exposure and toxicology data; (b) benefits from the use of the currently registered termiticides outweigh potential risks; (c) the NAS interim exposure level (5 $\mu g/m^3$) is useful guidance for long-term continuous exposure; and (d) EPA will fully assess the health risks and determine further regulatory action when necessary toxicology and exposure data are available.

B. McConnell AFB

1. Housing Construction

There were 485 housing units constructed on McConnell AFB in 1959 using a partial crawl space and partial basement design. Nine different room designs exist for this type house with the crawl space located below bedrooms or below common living areas dependening on the floor plan. The furnace and ventilation system are located in the basement with the supply and return air ductwork in the crawl space. See Figure 1. The return air ducts are formed using the wooden floor joists and sheet metal to shape an air chamber. Supply air is routed to floor registers through sheet metal ducting.

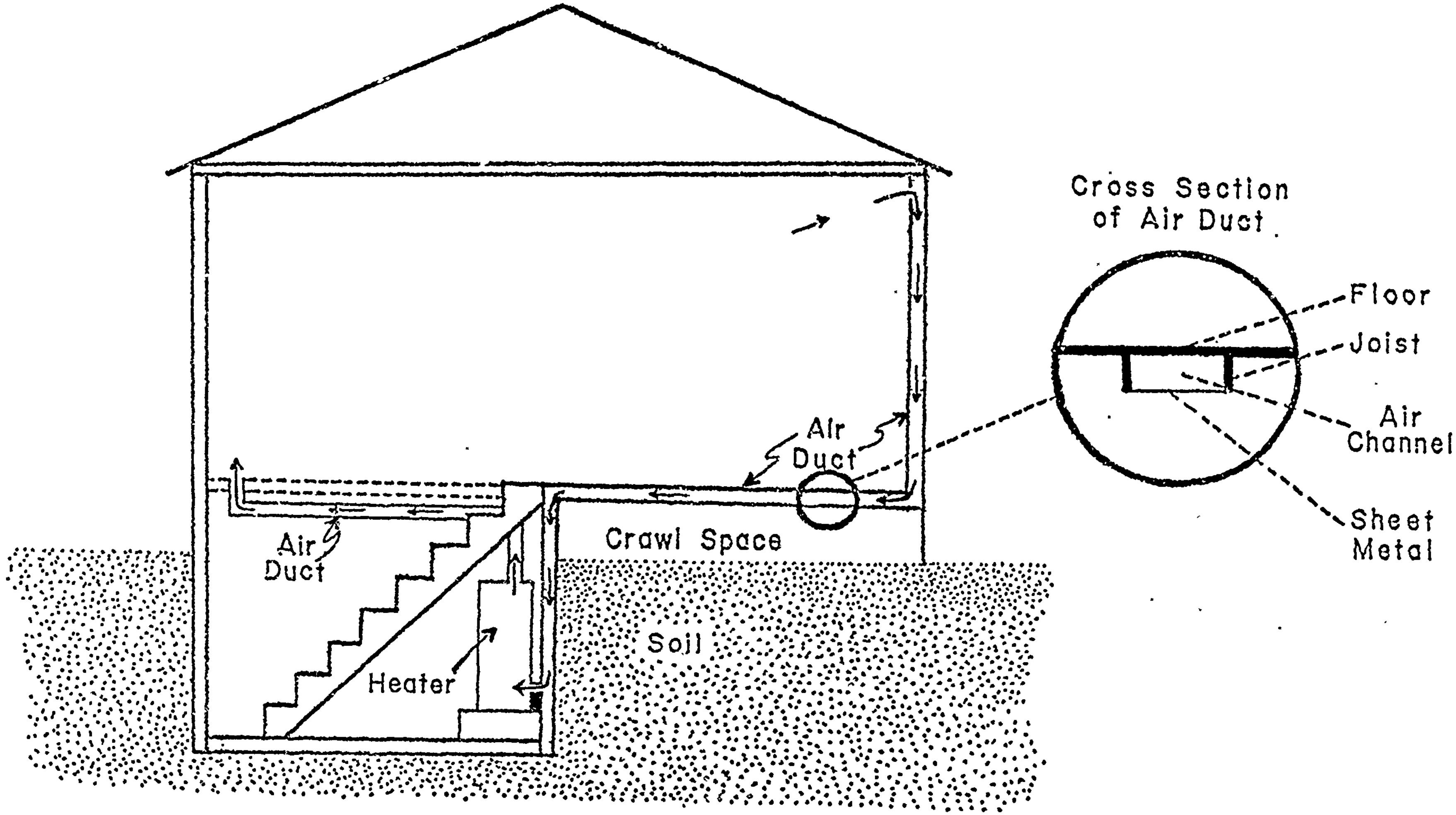


FIGURE 1

TYPICAL CONSTRUCTION OF PARTIAL CRAWL SPACE/PARTIAL
BASEMENT HOUSES AT McCONNELL AFB

2. Termiticide Treatment

All 485 crawl space units were treated with 1% chlordane water emulsion in 1974 and 1979. The houses were retreated in 1979 because the high number of in-house treatments required in the interim years (62 total) indicated the 1974 treatment did not adequately suppress termite infestation. The 1979 treatment consisted of the following methods: application of chordane around all building exterior perimeters by rodding, through holes drilled through concrete slabs, and through holes drilled in the brick veneer; saturation of the soil in the crawl spaces adjacent to foundation walls and support piers, saturation of the wood sill surface in the crawl spaces; and drilling holes through the concrete slabs supporting block walls which support wood structures (such as carport roofs).

3. Initial Survey Results

Initial air sampling in the 485 housing units was accomplished during September and October 1981. Twenty-seven percent of the initial 485 houses sampled had concentrations equal to or above 5 $\mu g/m^3$. Seventy-three percent had less than 5 $\mu g/m^3$ with four houses having air concentrations below the detection limit of the analytical technique. The highest concentration was 46 $\mu g/m^3$.

4. Proposed Corrective Actions

In November 1981, five engineering modifications were evaluated by the USAF OEHL in nine housing units. The modifications included: positioning fiberglass insulation between floor joists, sealing and painting basement walls, laying a plastic cover over crawl space soil, installing a positive ventilation system in the crawl space, and putting a plastic cover between floor joists. Although test results of these five different modifications were inconclusive, cleaning and sealing air ducts, included as part of all modified quarters, appeared to effectively reduce chlordane levels. Duct cleaning, which entailed vacuuming accomplished by a contractor, was not supervised or monitored by the Civil Engineering (CE) function at McConnell AFB. During February-March 1982, polyurethane foam filters were installed by CE in place of normal furnace filters and tested by the USAF OEHL as another technique to reduce chlordane concentration. A North Carolina State University research team had reported that polyurethane filters had been used to collect chlordane. A preliminary study in four houses at McConnell AFB indicated that polyurethane filters installed in place of the normal furnace filter could possibly reduce chlordane concentrations in the crawl space houses. A more extensive USAF OEHL-sponsored study of the polyurethane furnace filter ensued.

5. Filter Effectiveness Study[4]

From June into September 1982, the USAF OEHL and the McConnell AFB Bioenvironmental Engineering Services (BES) conducted a study to determine if a polyurethane filter installed in place of the standard furnace filter could effectively reduce airborne chlordane concentrations in family housing units at McConnell AFB. Twenty crawl space houses with a similar floor plan were

used for the study. The 20 houses were divided into four groups of five houses; a control group and 30, 60 and 90 day filter removal groups. The study concluded that although the polyurethane filters adsorbed chlordane, airborne levels remained above 5 $\mu g/m^3$ in most of the study houses during the summer months. Optimum effectiveness time to leave the filters in place could not be determined from the data. One important finding of this study was that chlordane concentrations increased directly with outside and crawl space temperatures; consequently, reduced chlordane concentrations should occur during winter months. The USAF OEHL recommended that engineering studies be initiated to explore additional techniques to eliminate chlordane intrusion into the crawl space houses at McConnell.

6. Proposed Engineering Modifications

Representatives from HQ AFMSC/SGPA, HQ USAF/LEEV, HQ SAC/SGPB and DEM, USAF OEHL/CV and ECH, HQ AFESC/DEVN and McConnell AFB participated in a January 1983 meeting to discuss possible engineering modifications for evaluation. Two modifications were developed: (a) sealing the crawl space soil with a concrete cover, and (b) closing the return air ducts from the crawl space, rerouting the return air inside the house and completely sealing the crawl space from the basement. The modifications were to be tested singularly and in combination.

III. ENGINEERING MODIFICATION STUDY PROTOCOL

The objective of this study was to evaluate the capability of these engineering modifications to control chlordane intrusion into the houses. The study protocol was developed by USAF OEHL and reviewed/approved by HQ AFMSC/SGPA, HQ USAF/LEEV, HQ SAC/SGPB, HQ AFESC/DEVN and McConnell AFB/SGPB.

A. Experimental Design

Twenty crawl space houses with a similar floor plan were used in this study. Fifteen of these houses were also involved in the filter effectiveness study. The houses were separated into four groups, five houses per group. The groups were designated by the modifications installed: control (no modification), concrete seal, reducted and crawl space sealed from the basement, and combination (concrete seal plus reducting).

Polyurethane filters were installed adjacent to the standard furnace filter in all except the control houses. The polyurethane filters were replaced every 30 days in the remaining 15 study houses as recommended in the USAF OEHL polyurethane filter study[4].

Sampling began in February 1983 and samples were collected once per month in all twenty houses until the engineering modifictions were completed at which time the polyurethane filters were removed and sampling was accomplished every 15 days through September. Following removal of the polyurethane filters, new standard (nonpolyurethane) furnace filters were installed in the ventilation system of all study houses prior to initiating bimonthly sampling. The study houses, except the controls, remained occupied during

this period. Normal temperatures were maintained inside the control houses in an effort to simulate occupancy and limit a source of variability.

B. Sampling and Analytical Techniques

Every attempt was made to control sources of variability during sample collection. Variability in the time of day, collection pumps, and pump location were considered. Samples for each individual house were collected at the same time each day. The pump initially used in a given house was used in that house for the duration of the study. The sampling tube was located three feet off the floor in the center of the living room.

The sampling train consisted of an electric Millipore^{R} miniature vacuum pump with a SKC sampling tube containing Chromosorb^{R} 102 as the collecting medium. The sampling tubes were connected to the pump by a small piece of Tygon^{R} tubing. Flow rates were measured with a Gilmont precision rotameter after the pump was turned on and again at the end of the sampling period. The rotameter was calibrated at the USAF OEHL with a bubble meter. When a slight drop in flow rate occurred, the beginning and ending flow rates were averaged to obtain a mean flow rate. The flow rates were approximately 4.0 liters per minute for all samples.

The following conditions were recorded during the sample period: inside temperature, outside high and low temperatures and uncorrected barometric pressure (obtained from the base weather service), and crawl space temperatures (both at the wood joists and just above the soil or concrete which ever was applicable).

Samples were forwarded to the USAF OEHL for analysis following the completion of each 20 house sample sequence. Analysis was performed by the USAF OEHL Analytical Services Division according to methods established by Thomas and Seiber[12] and Thomas et al[13].

IV. RESULTS

Typical construction for the partial crawl space/partial basement houses at McConnell AFB is shown in Figure 1. The three groups of houses (five units per group) were modified as follows:

A. Sealing the crawl space soil - approximately two inches of concrete (gunnite) was applied over the entire soil area in the crawl space to produce an unbroken cover. No other changes were made, the return air ducts within the crawl space remained functional.

B. Rerouting return air - the return air duct from the furnace into the crawl space was removed and resultant open portals into the living area sealed. The basement wall adjacent to the crawl space was sealed with a latex caulk where the concrete met the wood floor joists. Also, the port where the return air duct went through the basement wall was sealed with a wood panel and caulked. A large grille was installed upstairs in the wall adjacent the

basement stairway; consequently, no return air passed through the crawl space. The upstairs acted as a plenum; return air was routed through the grille and basement to the furnace where it was tempered and redistributed.

C. Combination - all modifications noted in A and B above were accomplished.

The airborne chlordane sample results (298) measured in the study houses and the environmental conditions under which the samples were collected are shown in Tables 1 and 2 respectively.

Figure 2 shows how the mean airborne chlordane concentrations per house group progressed by sample date; also plotted are the mean daily temperature as provided by the Base Weather Service at McConnell AFB. The mean concentrations by group for all pre-modification samples (Feb, Mar and Apr) were essentially the same; 2.82 $\mu g/m^3$ reducted, 2.86 $\mu g/m^3$ combination, 2.93 $\mu g/m^3$ sealed and 3.43 $\mu g/m^3$ control.

V. DISCUSSION

Chlordane levels found in the houses after modification showed a considerable difference between the control houses and the modified houses. Figure 2 suggests that the concrete seal modification will maintain chlordane levels below 5 $\mu g/m^3$ through the critical warm summer months, and reducting will not. The question of statistical significance between the three separate modification data will be addressed later.

Figure 2 also indicates that the mean daily ambient air temperature has a positive correlation with chlordane concentrations within the houses. The polyurethane filter effectiveness study[4] found a direct correlation between ambient air and crawl space air temperature versus chlordane concentration in the control houses. Figure 3, control house chlordane concentration versus crawl space temperature, corroborates this relationship.

The correlation coefficient (r) measures the strength of a linear relationship between two parameters, in this case temperature versus chlordane concentration. A $r = 1.0$ shows a perfect linear relationship and a $r = 0.0$ means no correlation between variables. Study data yielded the following correlation coefficients:

control house concentration vs crawl space air temperature $r = 0.89$

chlordane concentration vs ambient daily means air temperature

control group $r = 0.87$

The filter effectiveness study showed a correlation coefficient of 0.82 for chlordane concentration versus crawl space air temperature in houses control. The $r = 0.89$ and $r = 0.87$ for crawl space and ambient daily mean air temperature respectively versus chlordane concentration found in this study further demonstrates the strong direct relationship between temperature and concentration.

Table 1

Chlordane Concentrations in Air – $\mu g/m^3$

Sample Day

Group	Pre-modification			Post-modification										
	15-18[1] Feb	15-16 Mar	15-20 Apr	2-3 May	16 May	1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug	1 Sep	15 Sep	3 Oct
Control Houses														
2800 Westover	4.94	9.12	1.80	2.73	3.07	3.59	6.71	7.44	6.17	6.83	14.0	12.5	11.8	14.4
2900 Westover	2.21	1.43	1.60	2.17	6.49	4.40	5.94	11.1	8.96	12.7	15.8	13.8	15.3	16.7
2916 Westover	6.60	4.86	3.50	3.92	0.74	3.58	7.81	15.2	12.2	17.2	17.1	14.0	19.3	31.7
2917 Fairchild	3.94	5.19	4.46	11.8	17.0	15.4	14.8	15.3	11.2	20.5	24.7	17.1	16.8	24.9
2904 Fairchild	0.93	0.67	0.23	0.79	0.89	1.24	2.87	9.09	6.07	11.5	7.51	4.22	5.77	8.98
Mean	3.72	4.25	2.32	4.28	5.63	5.64	7.62	11.6	8.92	13.8	15.8	12.3	13.8	19.3
Reducted Houses														
2916 Andrews	2.36	2.98	1.70	2.96	3.25	2.54	3.12	3.54	3.28	4.62	4.24	5.65	1.97	6.31
2917 Andrews	5.04	4.43	4.12	2.78	5.23	4.62	8.05	9.02	5.64	7.38	4.76	8.12	8.47	7.76
2928 Andrews	2.29	2.22	2.06	1.59	1.51	2.28	5.94	6.93	10.1	5.96	4.07	5.75	6.99	8.44
8416 Craig	3.09	4.75	2.01	3.24	2.39	4.45	4.02	4.12	6.05	6.30	3.39	2.76	4.63	4.92
8212 Cannon	1.55	2.54	1.28	2.11	1.52	1.63	2.07	4.02	3.69	3.31	4.44	3.75	4.35	4.45
Mean	2.86	3.38	2.23	2.54	2.78	3.10	4.64	5.53	5.74	5.51	4.18	5.20	5.28	6.38
Sealed Houses														
2945 Fairchild	0.37	1.08	0.65	0.87	0.94	0.65	1.40	1.94	1.89	2.51	1.37	1.98	3.03	5.29
2944 Fairchild	1.90	2.32	1.43	1.74	2.09	1.80	1.67	2.54	2.02	3.70	1.94	2.66	1.44	3.20
2805 Westover	2.82	2.54	2.23	1.71	0.82	0.55	1.76	2.87	2.84	4.87	0.11	4.02	3.41	2.91
2920 Westover	3.87	2.49	1.59	NS[2]	NS[2]	1.33	2.16	2.71	2.73	3.11	2.55	2.61	1.85	1.30
2903 Mitchell	9.86	7.02	3.77	4.83	4.43	4.62	6.41	5.28	6.01	7.05	5.80	6.49	5.13	6.45
Mean	3.76	3.09	1.93	2.29	2.07	1.79	2.68	3.07	3.10	4.25	2.35	3.55	2.97	3.83
Combination Houses														
8101 Harmon	2.82	5.42	3.15	3.03	2.60	2.08	3.31	3.63	3.93	5.08	3.58	4.52	4.40	4.31
3101 Fairchild	2.84	6.75	3.17	5.87	4.26	5.04	5.44	5.03	5.56	6.02	6.33	4.89	6.02	5.41
3024 Westover	2.24	2.86	2.72	2.08	1.85	1.92	3.34	4.34	2.77	4.62	5.17	4.61	4.61	5.72
3032 Westover	1.87	2.62	0.75	1.04	1.19	1.01	3.98	6.29	2.54	2.53	2.64	2.76	2.71	1.44
8624 Westover	1.67	2.35	1.59	1.55	1.56	2.34	2.98	3.97	3.24	3.86	4.08	4.38	4.70	4.79
Mean	2.29	4.00	2.29	2.71	2.29	2.48	3.81	4.65	3.61	4.42	4.36	4.23	4.49	4.33

[1] Mean value of two concurrent samples per house
[2] No sample taken

Table 2

Environmental Conditions

Sample Dates	15-18 Feb	15-16 Mar	15-20 Apr	2-3 May	16 May	1 Jun	15 Jun	1 Jul	15 Jul	1 Aug	15 Aug	1 Sep	15 Sep	1 Oct
Outside Air Temp (°F)														
Range	36-57	40-66	37-52	48-62	56-63	46-70	64-78	74-93	72-78	78-98	79-100	69-86	66-77	69-77
Mean	44	52	43	54	60	58	71	83	75	90	87	79	70	71
Inside Air Temp (°F)														
Range	60-75	60-73	60-75	60-80	60-75	64-78	68-76	68-82	68-80	64-86	71-84	63-85	70-81	70-82
Mean	71	68	73	69	69	70	72	75	75	76	77	74	74	76
Crawl Space Temp (°F) at Wood Joists														
Range	50-66	54-70	54-68	55-68	57-66	59-68	64-72	68-75	66-75	70-75	68-81	63-81	68-75	70-77
Mean	61	61	58	61	60	64	68	71	72	72	73	72	72	72
Crawl Space Temp (°F) at Soil or Slab														
Range	52-68	54-71	52-68	57-70	59-64	61-70	61-72	66-73	64-73	68-73	66-79	66-79	64-75	66-73
Mean	61	66	59	63	62	65	66	69	69	70	72	70	70	71
Uncorrected Barometric Pressure (in. Hg)	28.58	28.27	28.65	28.44	28.37	28.40	28.60	28.41	28.51	28.69	28.59	28.67	28.45	28.43

NOTES: Crawl space and inside air temperatures were measured by survey personnel. Outside temperature and barometric pressure data was provided by the Base Weather Service.

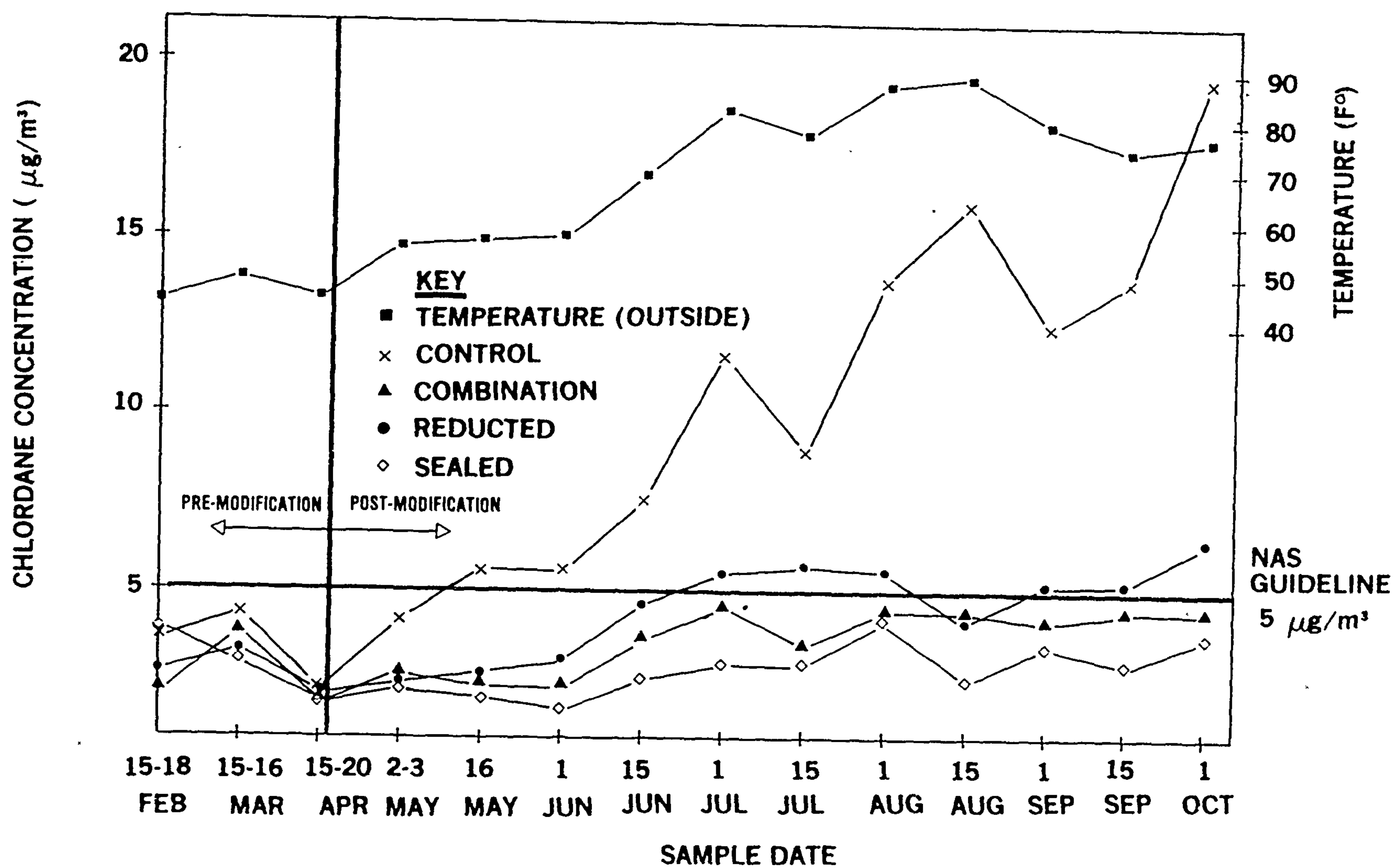
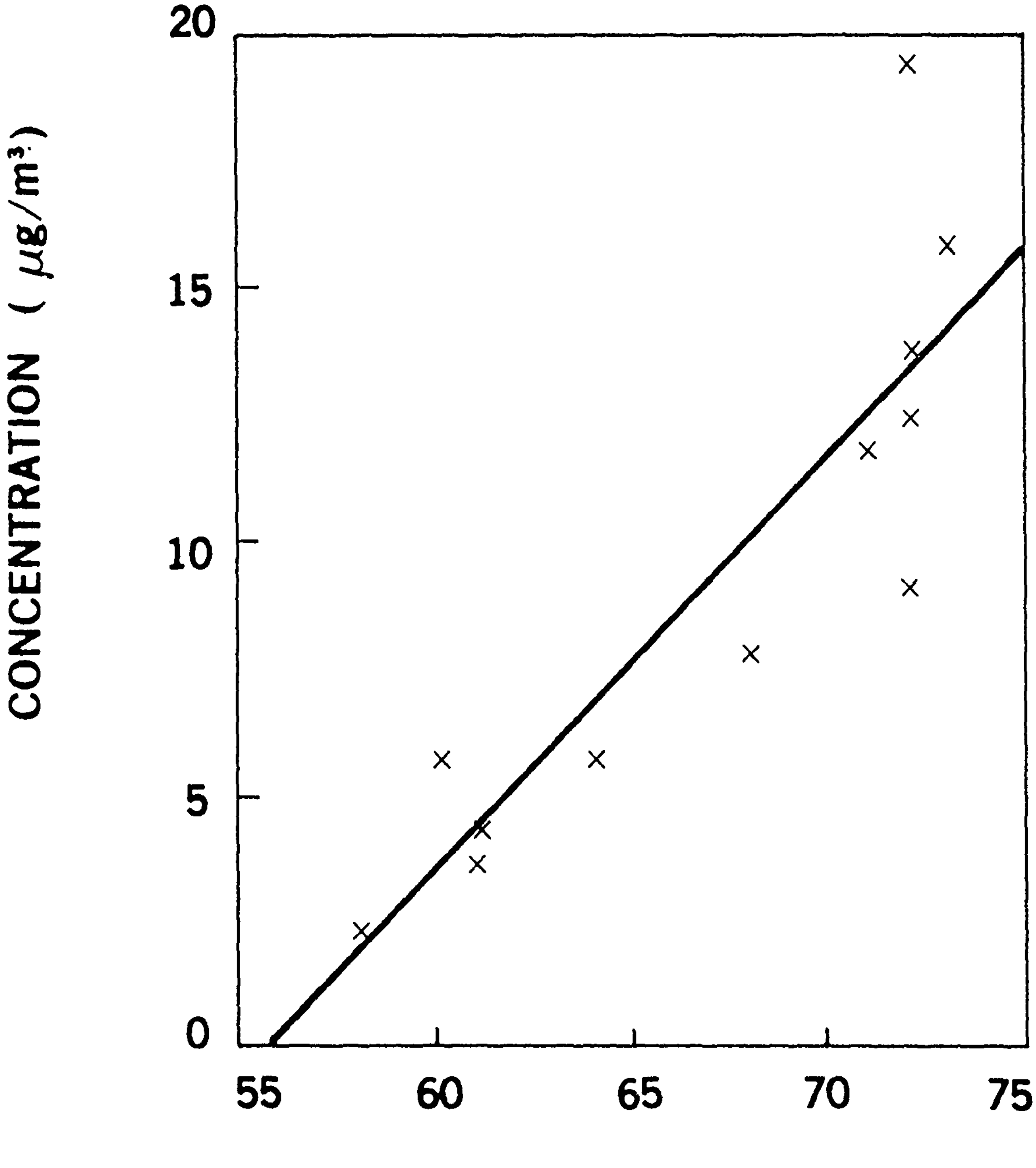


Figure 2

Chlordane concentration and mean daily air temperature versus sample date

FIGURE 3

CONTROL HOUSE
CHLORDANE CONCENTRATION (MEAN)
VERSUS
CRAWL SPACE TEMPERATURE



Although the mechanism of chlordane intrusion into the living area of these crawl space houses is not fully understood, it has been theorized that chlordane contaminated air in the crawl space penetrated the return air ventilation system, which is under negative pressure, and was then redistributed through the house[4]. Elimination of this negative pressure ducting within the crawl space probably accounts for the lower airborne chlordane concentration found in the reducted houses. The concrete seal may be reducing chlordane vaporization by two mechanisms: (1) establishing a barrier between the chlordane treated soil and air, thus preventing or greatly reducing release of chlordane into the crawl space, and (2) possible lowering of the soil temperature, which would also decrease chlordane vaporization. Table 3 compares pre- and post-modification chlordane concentrations per individual house. As already noted, airborne chlordane concentrations rose with increasing temperatures through the summer months. Consequently, it is not surprising that the post-modification concentrations are higher than those before the modification. Post-modification concentrations increased 215% in control houses, 64% in reducted houses, 0% in sealed houses, and 32% in combination houses. In addition, the mean chlordane concentration for May through September in all five control houses exceeded 5 $\mu g/m^3$, but was only exceeded in two reducted houses and one each sealed and combination house. Four houses showed a lower post-modification chlordane concentration; three were sealed and the other a combination modification. Samples which exceeded 5 $\mu g/m^3$ following modification completions were: control group - 76% (42/55), reducted group - 35% (19/55), sealed group - 17% (9/53), and combination group - 24% (13/55). Of the nine samples which exceed 5 $\mu g/m^3$ in the sealed houses, eight were measured in 2805 Mitchell; this house also had the highest pre-modification mean concentration 6.88 $\mu g/m^3$. Interestingly enough, post-modification chlordane concentrations in 2805 Mitchell were 17% lower than pre-modification levels.

The direct correlation between chlordane concentration and ambient outside temperature suggests that most unmodified crawl space houses would have airborne chlordane concentrations below 5 $\mu g/m^3$ during part of the year. This was addressed during the polyurethane filter study[4] and data gathered during the study reported here reinforce the previous conclusions. The following summary is based on a sample population of 97:

A. At outside temperatures $\geq$60°F, all (21 of 21) concentrations were >5 $\mu g/m^3$.

B. At outside temperatures <60°F, 75% (57 of 76) were <5 $\mu g/m^3$.

C. At outside temperatures <55°F, 82% (54 of 66) were <5 $\mu g/m^3$.

D. At outside temperatures <50°F, 92.5% (37 of 40) were <5 $\mu g/m^3$.

Based on this and the temperature data in Table 4, one can infer that 92.5% of the samples taken in November through March and 75% in November through April should show chlordane concentrations less than 5 $\mu g/m^3$.

The post-modification data were evaluated by the USAF School of Aerospace Medicine Data Sciences Division (USAFSAM/BR). The analysis used

Table 3

Mean Chlordane Concentration for Pre- and Post-Modification in Individual Houses

Group	Mean (μg/m³) Pre	Post	No. Samples >5 μg/m³
Control			
2800 Westover	5.29	8.11	8
2900 Westover	1.75	10.30	9
2916 Westover	4.99	12.98	8
2917 Fairchild	4.53	17.22	11
2904 Fairchild	0.61	5.36	6
Mean	3.43	10.79	
Reducted			
2916 Andrews	2.35	3.77	2
2917 Andrews	4.53	6.53	8
2928 Andrews	2.19	5.41	7
8416 Craig	3.28	4.21	2
8212 Cannon	1.79	3.21	0
Mean	2.82	4.63	
Sealed			
2945 Fairchild	0.70	1.99	1
2944 Fairchild	1.88	2.34	0
2805 Westover	2.53	2.35	0
2920 Westover	2.65	2.26	0
2908 Mitchell	6.88	5.68	8
Mean	2.93	2.92	
Combination			
8101 Harmon	3.80	3.68	1
3101 Fairchild	4.25	5.44	9
3024 Westover	2.61	3.73	2
3032 Westover	1.75	2.56	1
8624 Westover	1.87	3.40	0
Mean	2.86	3.76	

Table 4

Annual Temperature Data – McConnell AFB*

Month	Maximum Mean (°F)	Minimum Mean (°F)
Jan	41	21
Feb	46	26
Mar	54	33
Apr	67	46
May	77	56
Jun	87	66
Jul	91	70
Aug	90	69
Sep	81	60
Oct	72	50
Nov	54	35
Dec	44	26

*Data provided by Base Weather Service, McConnell AFB.

Table 5[14]

Approximate Degree of Confidence (γ) That a Specified Proportion (P) of Houses Will Not Have Chlordane Concentrations Exceeding 5 $\mu g/m^3$

	For P = .75		For P = .90	
Date	Reduct	Sealed	Reduct	Sealed
May 2	.99+	.81	.96	.55
May 16	.83	.85	.52	.62
Jun 1	.82	.93	.51	.74
Jun 15	.12	.72	<.10	.33
Jul 1	<.10	.85	<.10	.55
Jul 15	<.10	.74	<.10	.35
Aug 1	<.10	.28	<.10	<.10
Aug 15	.88	.77	.60	.41
Sep 1	<.10	.55	<.10	.16
Sep 15	<.10	.82	<.10	.51
Oct 1	<.10	.39	<.10	<.10

hypothesis testing (t - tests) and tolerance limit estimations to determine if any statistical significance existed between the effectiveness of the concrete seal and reducting modification to reduce chlordane intrusion into the house. For each individual post-modification sample period, the "Students t - distribution" was used to compare the control, sealed and reducted groups against each other and also against the 5 $\mu g/m^3$ guideline. Generally, the results showed that the chlordane levels of the control group significantly exceeded 5 $\mu g/m^3$ from 1 July to 1 October, and they were significantly higher than those of the other two groups ($p < .05$). The sealed and reducted houses, on the other hand, were never found to exceed 5 $\mu g/m^3$. There was no statistically significant difference ($p < .05$) between the sealing or reducting modification to prevent chlordane intrusion. However, all of the above testing is based on a small sample size and chances are low for detecting anything other than large differences. That is, differences may exist which are simply not detectable because of the small sample sizes. One can infer that either the reducting or concrete sealing modification significantly reduce chlordane intrusion into these crawl space houses.

The t-tests discussed above give information on what will happen <u>on the average</u> when houses are sealed or reducted. The tolerance limit approach may more appropriately predict what might happen to the population of houses that receive a particular modification. The Upper (γ, P) Tolerance Limit, shown in Table 5, is a value such that you can be γ% confident that at least P% of the modified houses will have chlordane levels below 5 $\mu g/m^3$. For example, on June 15, we can be 72% confident that 75% of the houses which received the concrete seal modifiction will not exceed 5 $\mu g/m^3$; and we can be 33% confident that 90% of the sealed houses will not exceed 5 $\mu g/m^3$. This analysis is rather conclusive in stating the poor confidence (<10%) we would have in the reducting modification. Here also, the degree of confidence is impacted by the small sample size, but the trend is obvious.

The combination modification data were not statistically tested because either the reducted or seal modification appeared as effective as the combination. The standard deviation (SD) by sample date for reducted houses varied from 0.5-2.7, for sealed houses it ranged from 1.3-2.1. This may imply a greater confidence in the ability of the sealing modification to consistently reduce chlordane levels.

Although there was no significant statistical difference among any of the three modifications, the consistently higher levels found in the combination group, when compared to the sealed group, was totally unexpected. One possible explanation could be the existence of a small chlordane "sink" in the basement. As return air moves across the basement to the furnace for retempering and redistribution, it may pick up minor amounts of chlordane.

VI. CONCLUSIONS

A. A strong positive linear correlation exists between air temperature (outside and crawl space) and airborne chlordane concentrations in the crawl space houses at McConnell AFB.

B. The sample data indicate that the reducting or concrete seal modifications will reduce chlordane intrusion into the living area of the house as well as the combination modification. Therefore, the combination modification is not necessary.

C. Although there was no significant statistical difference between the concrete seal and the reducting modifications, a much higher level of confidence can be placed on the ability of the concrete seal to keep chlordane levels in these houses below 5 $\mu g/m^3$.

D. Sealing the crawl space soil with concrete potentially reduces chlordane intrusion by two mechanisms: (1) establishing a barrier between the chlordane treated soil and the air, and (2) possibly lowering the soil temperature. Reducting probably reduced chlordane infiltration into the house by eliminating its entry mechanism via the negative pressure return air duct.

E. Chlordane levels in these houses should remain below 5 $\mu g/m^3$ from November through March because of low ambient air temperature. Most houses should remain below 5 $\mu g/m^3$ from November through April.

VII. RECOMMENDATIONS

A. The 485 crawl space housing units on McConnell AFB should be modified by installing a 2-3" concrete barrier over the crawl space soil similar to that of the study houses.

B. The houses should be modified before the return of warm summer temperatures.

C. As an interim precaution, polyurethane filters should be installed in all houses with chlordane levels greater than 5 $\mu g/m^3$. Filters should be replaced every 30 days.

D. Follow-up sampling by the base BES should be performed during the summer to document the concrete barrier's ability to maintain low chlordane intrusion levels. Sampling 5% (or 25 houses) should be sufficient to assess the barrier's effectiveness.

References

1. Lillie, T.H. Chlordane in Air Force Family Housing: A Study of Houses Treated Prior to Construction. USAF OEHL TR 82-9, USAF Occupational and Environmental Health Laboratory, Brooks AFB TX, Jun 1982.

2. Barnes, E.S. Chlordane in Air Force Family Housing: A Study of Slab-on-Grade Houses. USAF OEHL Report 83-129EH111DPB, USAF Occupational and Environmental Health Laboratory, Brooks AFB TX, Apr 1983.

3. Lillie, T.H. Chlordane in Air Force Family Housing: A Study of Houses Treated After Construction. USAF OEHL TR 81-45, USAF Occupational and Environmental Health Laboratory, Brooks AFB TX, Sep 1981.

4. Barnes, E.S. An Evaluation of Filter Effectiveness for Removing Airborne Chlordane in Crawl Space Houses at McConnell AFB KS. USAF OEHL Report 83-069EH118MPB, USAF Occupational and Environmental Health Laboratory, Brooks AFB TX, Dec 1983.

5. National Academy of Science, An Assessment of the Health Risks of Seven Pesticides Used for Termite Control. National Academy of Sciences Press, Aug 1982.

6. Fishbein, W.J., J.V. White and H.J. Isaacs, Survey of Workers Exposed to Chlordane. Ind. Med. Surg. 33:726-727, 1964.

7. Princi, F. and G.H. Spurbeck, A Study of Workers Exposed to the Insecticides Chlordane, Aldrin and Dieldrin, AMA Arch. Ind. Hyg. Occup. Med. 3:64-72, 1951.

8. Wang, H.H. and B. MacMaHon. Mortality of Workers Employed in the Manufacturer of Chlordane and Heptachlor, J. Occup. Med. 21:745-748, 1979.

9. Shindell and Associates. Report of Epidemiologic Study of the Employees of Velsicol Chemical Corporation Plant, Marshall IL, Jan 1946-Dec 1975, Milwaukee WI. Unpublished.

10. TLV Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1983-84, ACGIH, Cincinnati OH, 1983.

11. Environmental Protection Agency, Analysis of the Risks and Benefits of Seven Chemicals Used for Subterranean Termite Control. EPA, Wash DC, Nov 1983.

12. Thomas, T.C. and J. Seiber, Chromosorb 102, An Efficient Medium for Trapping Pesticides from Air. Bull. Environ. Contam. Toxicol, 12:17-25 (1974).

13. Thomas, T.C., J.W. Jackson, and Y.A. Nishioka, Chlordane Sampling Efficiency with Chromosorb 102 and Ethylene Glycol, Am. Ind. Hyg. Assoc. J. 41:599-601 (1980)

14. Odeh, R.E. and D.B. Owen, Tables for Normal Tolerance Limits, Sampling Plans and Screening, Marcel Dekker, Inc., NY NY, 1980.

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